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ABSTRACT

Microcomputers are already in a majority of American schools, but little is known about their integration into the school curriculum. This study examines the features of an elementary school--Skyline School in the South San Francisco Unified School District (California)--that have contributed to the successful integration of computers in its curriculum. Because implementation of computers must be seen both as an educational innovation and as a distinct educational technology, their successful integration in the curriculum requires unique site, district, and regional supports. Other features conducive to the success of the program have been a favorable school climate, ongoing teacher training, and active promotion by the principal. The analysis concludes with district and regional policy implications of this example, including issues such as hardware and software acquisition and adequacy, articulation of the curriculum, and provision of training, maintenance, and ongoing help. An appendix provides a methodological note on the case study. References are included. (Author/TE)

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SCHOOL OF EDUCATION STANFORD UNIVERSITY

Project Report No. 84-A13

SUCCESSFUL INTEGRATION OF MICROCOMPUTERS IN AN ELEMENTARY SCHOOL

Gail R. Meister

May 19[illegible]

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Gail R. Meister

May 1984

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Abstract

Microcomputers are already in a majority of American schools, but little is known about their integration into the school curriculum. This paper examines the features of an elementary school which contribute to the successful integration of computers in the curriculum. Because implementation of computers must be seen both as an educational innovation and as a distinct educational technology, their successful integration in the curriculum requires unique site, district and regional supports. The analysis concludes with policy implications.

INTRODUCTION

Microcomputers have arrived on the education scene. They have reached the national education agenda through reports of national commissions (e.g., National Commission on Excellence 1983); they are addressed in a majority of states (see Task Force on Education for Economic Growth 1983, for example); they are already present in a majority of the Nation's schools (Center for Social Organization of Schools 1983). In the five years since their introduction, microcomputers have spread rapidly, entering classrooms, schools and districts in largely uncontrolled, haphazard ways. Educators and policymakers now face the dual challenge of organizing a system that just grew and of directing its future growth.

Microcomputers belong to a class of technologically-based educational innovations whose advocates have historically claimed that they would improve and even revolutionize schooling. (cf., Papert 1980 and Pogrow 1983). Other innovations in this group are instructional television, radio, film and videodiscs. The most extreme of the claims promises that the technology will increase efficiency and quality at the same time. The argument runs that, unlike personnel, equipment (and the accompanying programs) represents a one-time expenditure, does not vary in quality, needs minimal supervision, and performs when and where needed without fatigue. An additional claim for the newer technologies asserts their superiority as a teaching method over traditional whole-group instruction by a teacher. Microcomputers' interactive capability permits more flexible and individualized tutoring and teaching than is usually possible in a classroom. To realize the fullest extent of these promises, microcomputers need to be closely tied to curriculum and utilized in classrooms; in other words, proponents

anticipate that microcomputers will be integrated in the curriculum and in the school.

Some participants in the policy debate about microcomputers dispute these claims, however, questioning the magnitude and scope of the change microcomputers can actually bring. Tyack and Hansot (n.d.), for example, review past technological innovations in schools and suggest that more moderate claims may be more realistic. These authors conclude that the availability of the technology in districts and individual schools historically neither guaranteed use nor produced the predicted revolution. Few cost-effectiveness analyses of educational techonology exist, but results obtained by Levin, Glass and Meister (1984) suggest that computer-assisted instruction is not substantially more cost-effective than some educational interventions for improving reading and math scores at the elementary level, and is less effective than others, such as cross-age tutoring. Other authors go so far as to question proponents' assumption about the educational and social value of microcomputers. Weizenbaum, for example, calls for a critical examination of this premise (Rosenthal 1983).

The lack of consensus on what constitutes appropriate and feasible implementation of microcomputers in schools is complicated by the lack of empirical evidence on the subject. Among the unresolved issues are concerns about equity of access and use (Hess and Miura, 1984, and Tyack and Hansot, n.d.). Other issues have to do with the definition of microcomputer integration in the curriculum and identification of those factors which contribute to successful integration.

This study examines the use of microcomputers in an elementary school. It focuses on the implementation features that have influenced successful integration; the goal is to highlight the policy variables and implications associated with this issue. The starting point of such an investigation--the definition of successful integration--is problematic, however. Researchers in this relatively new enterprise disagree on what marks successful integration. The various definitions suggest different policy implications. Integration could refer, for example, to the number of subjects and the number of different

applications (such as programming, drill and practice or simulation) for which the microcomputer is used, or to the number of teachers and students who use it. Some researchers and practitioners distinguish between microcomputer laboratories and microcomputers in the classroom, suggesting that microcomputers outside the classroom--in labs or hallways--"avoid the challenge of integrating (them) into classrooms and curricula" (Sheingold, Kane and Endreweit 1983, p.422). If integration means that microcomputers must be inside the classrooms of many teachers in a school, then sufficient resources and support to motivate and enable wide participation must be committed. And if integration also means that microcomputers must be used in many ways in many subjects, then sufficient resources and coordination to curricula and software available must be applied.

Given the absence of a standard definition for the integration of microcomputers in the curricula, a working definition is necessary. This working definition assumes that microcomputers are located in classrooms and are an institutionalized or regular and continuing part of the school's operation (Berman and McLaughlin 1972, p. 16). Successful integration of computers in the curriculum means the extensive use of computers in a variety of subjects and in a variety of applications, by a large proportion of a school's students and teachers. One expert has put it succinctly: "It's lots of teachers and lots of kids using computers in lots of ways" (L. Finkel, interview, 2/3/84).

Microcomputers' nature as both technology and innovation determines the features of successful integration. These features then determine some of the policy questions and inform policy decisions about microcomputers at the site, district, region, state and federal levels. On the one hand, integration of microcomputers requires--as does any educational innovation--such local features as teacher commitment, a supportive administrator, and symbolic and concrete district support. On the other hand, integration of microcomputers--as educational technology--also requires external support for the acquisition and maintenance of hardware, evaluation and acquisition of software, and training of teachers, students and parents. Public sector agencies may

share the responsibility for providing this external support, along with individuals and groups in the private sector.

The combination of technology and innovation in school use of microcomputers places two additional features on the list of those accompanying successful integration. One derives from the effect of microcomputers in the classroom on classroom management and student-teacher relationships. Integration of microcomputers demands policy to furnish the initial and on-going support to meet those special needs. The second additional feature derives from the fact that microcomputers embody both curriculum and instructional method. Policy at the state and local levels should therefore address articulation of the subejct across grade levels and schools, as well as the preparation and certification of teachers.

Berman and McLaughlin's (1977) definition of effective implementation adds one final feature with policy implications. According to them, effective implementation of any educational innovation occurs when "mutual adaptation" occurs. Mutual adaptation is the process whereby the innovation shapes itself uniquely to the site and participants adopt new ways to acommoodate it (p. 5). Such a definition notifies policymakers that a range or a variety of implementations can be considered successful. This notion in turn implies that variability or local choice in implementation features may require a corresponding flexibility in policy prescriptions.

In summary, microcompucers share characteristics of other non-technological educational innovations, yet are different from them. They also share some traits with other educational technologies, yet differ from them as well. Like other educational innovations or planned changes, the microcomputer innovation is not "self-executing" (Berman and McLaughlin 1977, p.12). Implementation of computers implicates the whole multi-layered system to which teachers, classrooms and schools belong (Berman and McLaughlin 1977, Bauchner et al. 1982, Fullan 1982). Successful integration requires some accomodation, acceptance or action by parts of the system at various times. Like other educational technologies, the implementation of microcomputers relies on machines.

But implementing microcomputers and integrating them into the curriculum mean more than merely acquiring hardware, a common but erronous view (cf. Pogrow 1983 who minimizes the personnel and other dimensions associated with hardware).

Successful integration is a complex organizational task. For example, the technology requires sophisticated maintenance and training personnel close by during use (and not just during training). Once teachers master operation of the machine and use it in their classrooms, their perceptions of the classroom itself begin to change. One cause of the change is that the microcomputer becomes a surrogate teacher for those students working with it. Not only does the machine represent another teacher in the classroom, but technically-adept students also act as teachers for other students, and sometimes for the teacher as well. This type of change can effectively alter classroom management from whole group to more individualized instruction. This is a profund structural change, similar to that required for innovations like individually-guided instruction. It may lie hidden behind the initial obstacle--or excitement--of simply mastering the machine. In other words, the introduction of this educational technology represents more than a mere tool or an alternative mode of delivering instruction. It is a complex and demanding innovation with non-obvious consequences for change.

In the next section, the features which have contributed to Skyline's successful integration of microcomputers (computers, hereafter) will be described drawing on but going beyond the literature of planned change. After summarizing those features, the policy implications will be discussed and further research will be suggested to help educators and policymakers meet the challenges that integration of computers in the curriculum poses.

SITE SELECTION

The K-6 elementary school selected for this study, Skyline School in the South San Francisco (CA) Unified School District, meets the

working definition of the successful integration of microcomputers in the curriculum. At the time of the study, spring 1984, the school's six mobile computers traveled to classrooms all over its campus, where all but one of the 25 teachers either used or intended to use them, and all students in the upper grades and some students in the lower grades were getting some experience with them. Both Skyline's RSP (Resource Specialist Program, formerly Educationally Handicapped Program) teacher and TLC (Tutorial Learning Center) teachers regularly used computers, as well. The principal has stated her intention that all 580 students from kindergarten to sixth grade will learn to use computers.

Computer use at Skyline resides in three principal applications and three main subjects: programming, drill and practice, and computer literacy are the applications, and problem-solving, math, and reading and language arts are the subjects. Fourth, fifth and sixth graders now all employ LOGO (a computer language developed by Sidney Papert for children which features a 'turtle' cursor) in problem-solving classes, while some third graders (in the "top math" group) are also beginning to do simple programming with LOGO. Fifth and sixth graders also use Bank Street Writer, a word processing program, for composing and editing language arts work. All students, including younger ones, use a variety of software for drill and practice in math, language arts and reading. The drill and practice takes the form of puzzles, learning games and timed practice on topics such as math facts, sentence structure, punctuation, capitalization, attribution, and, for the very youngest, letter recognition and counting. In addition to programming and drill and practice applications, all students who use computers are required to use them properly, so they have all received some facility in what could be termed computer literacy. Kindergarteners, who use the computer only with a teacher attending, know less than fifth and sixth graders, who use them independently and have passed tests on basic computer care. Only after school--in free play or occasionally at the Computer Club--do students use the computer for video games. The range

of subjects and applications, the extent of teacher and student participation, and the presence of computers inside classrooms, suggest that Skyline has successfully integrated computers in the curriculum.

SETTING

Set on a cold but commanding rise above the San Francisco Bay, Skyline Elementary School clears a space for the main buildings and portables of its single-storey campus, its front-yard parking lot and lawns, and its rear play area from the rows of tract homes which climb the windy hills all around. Skyline was built in 1967 and houses 580 students in kindergarten through sixth grade. Skyline's houses, its cars, its kids, all suggest middle class. The school fits with the neighborhood in that, like the homes nearby, it is modest and neatly kept. Whatever delicacy there is in the architecture of this typical California open-air plan is not visible from the front parking lot. Yet the tree at the crossroads separating the office from the multi-use building and half the classrooms from the other half in an E-shaped design is very pretty. The school is clean and innocent of a single vandal's mark.

According to the principal, 70 percent of the students at Skyline are Asian, mostly Filipino, with ten percent each of blacks, Spanish-surname and white. The striving blue collar white families which had made up this community have moved up and out--to more affluent (and warmer) homes in the suburbs to the south. The new Skyline community is upwardly mobile. On the whole, parents of most Skyline students work outside the home; they are eager for the education of, and any advantage for, their children. A number work with computers on the job, and some have computers at home. The school community, although overwhelmingly composed of minority famiilies, is not poor, and no specially-earmarked funds come to Skyline in that guise.

The staff numbers 25 teachers who, by several job-sharing schemes, fill the 22 classrooms, three part-time professionals (nurse, psychologist and speech therapist), and nine aides who, except for the English As a Second Language (ESL) aide, split their time among several classrooms each. Many have worked together at Skyline for a number of

years; for example, one teacher has taught there since the school opened. The principal, Barbara Loveless, has held that position for ten years, during which time no new elementary teachers have been hired in the district. Except for student teachers, the regular staff ranges in age from mid-thirties to low sixties with the average at 47 years. The women tend to wear skirts or dresses, or if slacks, not jeans. The one male teacher favors an elegant but understated casual style. Like the students and the computers, the teachers move briskly through the halls.

DISTRICT CONTEXT

It is "in tune with the district philosophy," as John Cradler, the district's Coordinator of Special Projects and Research, put it, to promote computer use. He cites the case of a former principal who insisted that computers be locked away in cabinets and who was replaced by an administrator interested in having them used. In a sustained period of reducing central office staff, the district is nonetheless moving aggressively to equip all schools with computers and to train staff to use them. The district's success in acquiring computers and encouraging their use may be seen in a comparison of statistics from January, 1982, and January, 1983. In 1982, the total number of students using computers was 1,086 in 17 schools; one year later, the number had more than tripled to 3,321. The district has allocated only $20,000 to $25,000 from internal funds to set up computer labs in each of the high schools, and has otherwise used external grant monies exclusively to attain this growth.

The district has assigned administrative responsibilities for computers to John Cradler. Because of central office staff reductions, he also is the district administrator for grant writing, testing and staff development. In practice, he estimates that he spends up to one-third of his time ("and more all the time," he adds) in computer-related work and often puts his considerable grant-writing talent and staff development authority to work to support the district's computer program. He convenes the Computer Cadre, a district-wide committee organized in Novembner, 1981, whosepurpose is to articulate

teaching about computers within the district, to review hardware and software, and to plan computer inservice training.

The commitment to the use of computers and the reliance on outside funding for the acquisition of hardware may set the South San Francisco Unified School District in a special category of successful early-adopting computer districts. It is special also in Cradler's grant-writing proficiency; between 1976 and May, 1983, he secured approximately $915,000 in competitive and categorical funding of which nearly $122,000 was allocated to the purchase of hardware and software for the district. The State Department of Education has recognized the district's computer distinction by awarding it a grant in 1984 to identify the problem-solving skills in the State's adopted language arts curriculum and to match them with appropriate software. Finally, the district is special because it contains Skyline School, whose principal and two of its teachers have worked closely with Cradler in developing special computer projects, offering training, and showcasing the integration of computers in their school.

THE COUNTY, STATE AND FEDERAL CONTEXT

The contribution of external agents to Skyline School's successful integration of computers is not trivial, and may be an additional condition of the school's and district's specialness. San Mateo County, the State of California and the federal government have all made a critical contribution to Skyline's status as a "premiere" computer-using school, to use the designation of LeRoy Finkel, Instructional Computing Coordinator at the County's Office of Education. The County has supported Skyline's success by providing the services of both LeRoy Finkel and the computer technology center. Under Finkel's direction, the County has become the training center for the State's 14 other technology centers, featuring hardware displays, a software library and an evaluation review center, as well as a public domain software exchange, SOFTSWAP. Skyline's chief or lead computer-using teachers, Beverly Hamilton and Beverly Saylor, who are known as "the two Bevs", participate in County activities, and offer some County inservice training sessions. Finkel himself advises the district's Computer Cadre

and acts as a mentor to the lead teachers at Skyline and throughout the County. He makes a point of keeping up to date and informing lead teachers of computer-related opportunities which might interest them.

Skyline is located within a well-known high technology area. The regional environment thus adds direct and indirect support to educational technology in schools through industry contacts, training opportunities in the community, and public awareness and interest. For example, Cradler attends new equipment training sessions at Apple, a local company, and teachers Hamilton and Saylor field test software for The Learning Company, another local firm. The State also indirectly supports information networks in which Finkel, Cradler and the Skyline lead teachers participate, such as Computer Using Educators (CUE), a state-wide group which sponsors meetings and publishes a periodical. A less formal but nonetheless powerful network is that of the State Department of Education's computer experts, with whom Cradler serves on legislative commissions.

The most important tangible contribution of the State and federal government to Skyline's computer success is funding. Except for staff salaries and some inservice training, Skyline's (and the District's) computer activities are overwhelmingly paid for by State and federal grants. Unlike non-technology based innovations, however, the computer hardware purchased with soft money remains in the school once the money is spent. Skyline's first computer and all other computers save one came from Title IVB (now Chapter 2) of the Elementary and Secondary Education Act (ESEA), a federal program. The other computer, Skyline's second, came from Skyline's adoption of a National Diffusion Network project on testing. The conclusion of that project left a computer, a printer and a double disk drive at the school.

SCHOOL CLIMATE

At Skyline, one notes a unity in standards and behavior among the teachers. This is accentuated by the centrality of the teachers' room in the physical plant and in the interaction among staff, for it is the place teachers and principal gather before school and during lunch periods. The teachers' room table is the place to bring doughnuts on

Friday, greeting cards one teacher is selling for a charity, and green cookies in the shape of turtles (to call attention to the birthday of Seymour Papert, founder of LOGO) for public view and consumption. The teachers' room is also the place Barbara Loveless, the principal, makes informal announcements, and where Bev Saylor, the teacher with computers as her adjunct duty this year, announces the arrival of computer peripherals and make public recommendations about new software. The sense of common purpose and common expectations comes not from the room, but from a commonality of style and a familiarity the years together have produced.

The uniformity embraces curricular priorities, organizational style and computer use. Principal and teachers make clear that reading and math are top priorities at Skyline, as they have been for a number of years. With the growth of computer use at Skyline and the work of Bev Hamilton and Bev Saylor, now sixth and fifth grade teachers, respectively, problem-solving (which features LOGO computer exercises, among other activities) has joined reading and math as a school-designated priority.

A single style, which can be characterized as traditional, describes classroom layouts, instructional methods and school decorum. Everyone at Skyline seems to take learning seriously. As students of all ages walk in order to departmentalized reading and math ability groupings, and as bunches of from two to five children wheel the school's six to eight computers from room to room, one sees both energy and control. This impression carries into the classrooms, where the desks are invariably configured in rows but where students work alone, in pairs or threesomes, or as a whole class on learning tasks. A kind of no-nonsense love emanates from the principal and teachers to students, ranging from the cheerful affection of some to the feisty caring of others. The whole ambience commmunicates attention to business without undue oppressiveness.

The established order, routine and agreement facilitates communication among staff and the introduction of computers at Skyline. As one teacher noted, "Orderliness and system are universal. It's easy to exchange kids, anything. Basically, there are the same rules, the

same standards, for all teachers." Such norms ensure that rules and schedules for the transport and use of computers are followed, but also facilitate the exchange of ideas, such as those about computers, and the flow of information, such as the kind of on-going training that computer-using teachers require.

TEACHER INITIATION OF COMPUTERS

Computers came to Skyline because of the independent interest of three teachers, the principal, and the district's research and development officer. Around 1979, teachers Robert Damico, Saylor and Hamilton all began taking computer programming courses on their own. Like many teachers who started the same way, the motivation included investigation into possible new career areas as well as curiosity about the capability of computers in education. The teachers continued taking courses and began talking to the principal, Barbara Loveless, about computers. As Damico's interest in learning levelled off, that of Hamilton and Saylor grew. Damico was able, however, to connect Loveless and the other two teachers to friends in the computer industry, who provided additional content for the women's interest in school computers.

In 1979 and 1980, Cradler's grant-writing prowess and the knowledge and enthusiasm of Loveless, Hamilton and Saylor netted Skyline the first two of what by spring, 1984, became seven Apple computers. Although initial funding was provided by federal ESEA Title IVB and Title IVC monies, later funding for hardware has been supplied almost exclusively by Title IVB. The first two computers saw service in classrooms: Hamilton and Saylor developed and taught a computer literacy course using one computer and Damico used the other for computer-assisted instruction.

Hamilton and Saylor, with Loveless's blessing, continued to work on other new projects. Starting in the spring of 1980, they offered computer workshops for teachers and parents, and arranged to fieldtest software for several commercial groups and school agencies shortly afterwards. Over the past four years, they have offered three instructional series (each more than once and each open to the rest of

the district at no cost to participants): an introduction to microcomputers, a BASIC programming course, and a LOGO course. They also developed a year-long problem-solving course for fifth and sixth grades, using LOGO paper and pencil and computer tasks as a central teaching strategy. Hamilton, Saylor and Loveless also participated in the district's Computer Cadre from its initiation in late 1981, helping to frame and carry out its purposes. The three Skyline women have continued to serve on the Cadre but report that it meets less frequently and generates less commitment from them. With Cradler and other district personnel, they have attracted State funding for a new project, Computhink, which provides released time for them to build on their experience with problem-solving and computers.

Hamilton, Saylor and Damico took the lead among other Skyline teachers who began in 1982 to use computers. Damico formed the Computer Club, an after school activity for fifth and sixth graders, as an adjunct duty. Loveless enabled Saylor, Hamilton and other teachers accompanying them to visit other computer-using schools. Largely as a result of the enterprise of these three teachers, Cradler's Microcomputer Survey for January 1983 shows that Skyline had 19 staff users at that time, out of a total of 74 staff users in the district's eleven elementary schools.

PRINCIPAL'S ROLE

Barbara Loveless has three qualities which make Skyline succeed with integrating computers into the curriculum: she is innovative, supportive and pro-active. "She likes new stuff," remarked Cradler, who has worked with her over the years she has been in the district, including the five years she was a curriculum consultant. And computers are new stuff for her. Second, she is supportive, an unprompted judgment volunteered by fully two-thirds of the teachers interviewed. One teacher explained that Loveless not only supports teachers generally, but that she particularly "backs up (the two Bevs) and gives them what they need."

Loveless's proactivity on behalf of computers makes for a long and varied list of resources and opportunities provided to teachers. Aside

from listening to her teachers on the potential of computers and actively seeking funding, she has done some "finagling" and made "deals" with the district office to trade old color televisions for new computer monitors, for example. She not only managed to acquire Skyline's seven computers without taking it out of her site budget (unlike film projectors), but she also managed to avoid paying for computer maintenance out of her budget. She has also freed monies for the "dribbly" items like cables, adapters and fans the computers needed, which "nickel and dime you to death," she said. Working with Hamilton and Saylor, she has been able to capitalize on their outstanding computer work to restrict expenditures on software. She estimates that, in all, Skyline has spent only about $500 on computers, "forever, since we've had them." Loveless has also freed time for teachers to work on computer-related matters and to visit other computer-using sites, and has sometimes arranged to fund such fieldtrips and training. She also facilitates the continued functioning of the computer program in homelier and miscellaneous ways, such as taking yard duty for Bev Saylor when she ran into a problem hooking up the new printer scheduled for use in another classroom that morning. That the machines are stored in her office means that students and equipment truck in and out at the beginning and end of the day. Further, she has also allowed students to use the machines in her office after school, usually for play, while she does paperwork and intermittently banters with the four regulars. In these ways, she has identified herself as being <u>for</u> computers.

COMPUTER MANAGEMENT

Computer management at Skyline is clearly demarcated and is a significant component in its success at integrating them in the curriculum. The management of computers necessitates active participation by the lead computer-using teachers and by students to get hardware and software at the right place and on time consistently. It presupposes sufficient training, good relations and communication among all teachers and students, but requires a major commitment of time and good will from the lead teachers. In this section, these three related issues will be treated separately.

Lead Teachers

In large measure, Skyline's computer system works because the lead teachers, Hamilton, Saylor and, to a lesser extent, Damico, make it work. Skyline's computer scheduling is done by either Hamilton or Saylor as a required adjunct duty in alternating years. In this capacity, the adjunct duty holder gathers and balances teachers' requests for computers and peripherals, publishes a schedule and coordinates computer hardware, software and the student computer movers. She also allocates computers for teachers' use at home on weekends and vacations, based on teacher requests. Since, except for public domain programs, individual software packages are copyrighted and a diskettes typically costs from $30 to $40, schools like Skyline generally cannot buy too many duplicates. Thus, keeping an adequate supply of software and keeping track of it when teachers borrow it and forget to return it, are also concerns for the teacher on adjunct computer duty.

The adjunct duty holder must adjust the schedule periodically throughout the year and absorb feedback from disappointed users. This year, for example, some teachers have just been added to the computer roster as they have become more proficient and as the introduction of computers has come to make more sense in their curriculum, e.g., they start later in the year with first graders. As demand increases, the adjunct duty holder inevitably hears complaints about the rationing. "Since I made up the schedule," Saylor sighs, "I keep getting notes (from teachers) saying, 'More time. We need more time.' But there is no time."

The lead teachers all have expertise to handle minor problems with software and hardware which present major stumbling blocks to novice users. All help, but the key troubleshooter is the adjunct duty holder. Before computers, teachers always used to call on Damico, the sole male teacher, when any equipment failed, but now they invariably call on whichever Bev is closer. Their expertise and encouragement are both considerable and well-known among staff. They are, in fact, the very people who taught most of Skyline's newer users almost everything

they know about computers. "It really helps to have the two Bevs," said one teacher. Most teachers made some similar remark, such as "I wouldn't have dared try it without knowing Bev was close by to help out."

Hamilton's and Saylor's extraordinary expertise represents a special bonus for Skyline, saving money, providing more operating computers more of the time, and encouraging more teacher users. The two women have obtained Level I Apple repair licenses, and can replace worn chips or keyboard pieces on the spot. Other schools would have to send out such machines to the district's one-day a week computer repair person, whose hours the Superintendent's Cabinet may increase up to full-time. The result is that teachers report feeling comfortable enough to experiment with using the machines in the first place, and have more of them "up"--available to use--more of the time.

Training

The training which has facilitated Skyline's integration of computers must be seen as a phenomenon of several layers, with different layers for different groups of actors. The lead teachers and other key district actors participate in one set of training experiences, while the majority of novice teacher users participate in another, and students and parents in still others.

The direct training for the majority of teachers consists of the early introductory workshop by the Lawrence Hall of Science mobile computer van and several workshop series by Hamilton and Saylor, all held at Skyline. Five teachers were taking the workshop held during my contact at Skyline; and two teachers had taken all three courses given. The principal estimates that most Skyline teachers have attended several computer workshops. In addition, some teachers have visited other schools or sites to see computers in use. The lead teachers encourage newer users to take computers home over weekends and holidays as part of their training, a policy designed to help them feel comfortable with the machines. That level of comfort, in which people feel free to "play," is at once the goal and the process for getting there.

The lead teachers' more sophisticated training indirectly supports the training they in turn provide for newer users. This more sophisticated training consists of the lead teachers' entrepreneurial venture into programming, along with district, County and other externally-sponsored activities. In the district, the Computer Cadre makes training and information about resources a regular part of its meetings. Other resources for the Hamilton, Saylor and Cradler include the County Office of Education under Finkel, meetings and conventions, and participation at the State level with CUE (Computer Using Educators, a teacher group). In addition, the community at large provided the initial impetus for the lead teachers, who first read about computers in the mass media, attended programming courses at community colleges, and had friends in local high technology firms supplying ideas at critical points. Further exposure to personal computers in their homes also adds to the training resources for this group.

Training of parents and students in the local community also indirectly supports the integration of computers at Skyline. The popular series Hamilton and Saylor have offered to parents create both a climate of acceptance and expectation for computer use in the classroom. Student proficiency on (and enjoyment of) computers enhances this effect in two ways. Students motivate teachers to learn about computers and furnish a reassuring secondary source of expertise in the classroom.

Substitute teachers report most strikingly how students motivate teachers to learn about computers. One said, "I used to tell them to take that thing away when they wheeled it (the computer) in. But I could see the kids were so disappointed." Not only student good will, but the substitute's ability to follow the day's lesson plan would thus be jeopardized. Together, these two forces provide a powerful incentive for substitutes to learn about computers. (One to whom I spoke had just become a full-time teacher at Skyline.) For teachers already in charge of their own classrooms, the pressure from students is more subtle but still real.

Students' Role

It is hard to envision Skyline's successful integration of computers without student help. The PTA (Parents and Teachers Association) donated some of the money for computer carts, but it is students who fetch computers from one location and deliver them to the next--which may occur up to five times in any one day for any one machine. They make sure the computer wears its stiff plastic jacket in the rain, and that it is lifted up steps into the portable classrooms, guided gently over sills, and steered slowly around corners of walls and ramps. The computer movers sometimes also plug machines in, load them, and occasionally fix minor problems in the process. Hamilton and Saylor have, through their access to all fifth and sixth graders in computer-based classes, trained a cadre of upper-grade volunteer computer movers. When parents agree, certain students are permitted to move computers throughout the school day. Student training is tied into a larger system of rewards called privileges which include prizes, but students seem to carry out the duty with alacrity and without regard to external rewards.

TEACHER COMMITMENT

Teacher commitment to the use of computers is one of several facets in Skyline's successful integration of computers. It relates in part to the initiative all teachers--and not just the lead teachers--must exercise in implementing computers in their own classrooms. It also relates to the positive evaluation teachers give to computers when they have evidence from their own and others' experience that computers can help and will not hurt their program. Commitment also relates to teachers' acceptance of the physical and perceptual changes in their classrooms which flow from the use of computers and which they may not have anticipated.

Barbara Loveless, the principal, cites the initiative component of teacher commitment as the most fundamental and essential feature of the computer innovation at Skyline:

> It comes down to personnel. You can't implement without staff or they'll buck you all the way. It has to come from down up, not top down. If you come in and tell them, "We're going to do it," they'll say, "We don't want computers...Teachers commit themselves.

All Skyline teachers readily admit that the Hamilton, Saylor and Damico have committed themselves to the integration of computers. Loveless contends that enough staff members are sufficiently committed to take over if one of the lead teachers left the school.

Teachers at Skyline are committed to the use of computers because they see positive results. They call the computer "a good tool," and "good reinforcement for the basics." One teacher in the Tutorial Learning Center crowed, "The computer can drill kids to death, but they don't mind." Removing the "drudgery" of learning, as another teacher put it, compensates both students and teachers. Moreover, these teachers appreciate the "good habits" and respect for property children acquire in working with the computer. Universally, what teachers like best about the computer is that students like it. "Kids get more out of it and they love it," said one teacher; said another, "I can't think of any kid who doesn't like it. I haven't heard any complain."

Another feature teachers at Skyline like about computers is that, for the most part, the acquisition of hardware and software through grants and donations has not pre-empted expenditures on other things in the site budget. Both principal and teachers speak with regret about time limitations in the school day that preclude doing more, but they generally seem to feel that computers do not deprive them of other material things. Loveless coordinates the distribution of discretionary funds through a democratic process, which teachers perceive as equitable. Not that there hasn't been "a lot of petty jealousy" over the use of special funds for equipment, but Loveless points out that teachers who object do not realize that those funds are restricted in any case.

The presence of even one computer in the classroom changes not only the physical space, but also changes the nature of control the teacher exercises--and teacher acceptance of the latter change is a profound index of acceptance, and integration, of the innovation. One teacher said she had to get used to allowing students to work on the computer and not work with her. Another touched on the same phenomenon but

stressed the freedom the computer gave her to work with other groups of students. These altered perceptions of classroom control are not among the first things to which teachers attend when contemplating and learning how to use computers. They confront instead the mystery of the machine, and only as they implement computers in their classrooms, do they come to realize the other, less obvious, more profound consequences of its use.

SUCCESS

The consensus at Skyline is that the integration of computers seems to be working, and the fact that it works, helps it work even more. Over time, more and more teachers try and succeed at using computers in the classroom. They are motivated to try this innovation because colleagues around them have tried and succeeded, because two outstandingly successful colleagues (who are gaining more and more attention within the district, the County, and even at Stanford University) are encouraging them to try, and because the principal puts resources and opportunities before them which also encourage them to try. Moreover, the principal has not truncated the time period in which teachers must make an effort to learn. The combination of an open-ended time line, a strong expectation from the principal, the district, parents, and students--all of whom are for computers--that teachers will try, and the provision of necessary resources also contribute to Skyline's success. Only one teacher has discontinued using computers in her classroom. The overwhelming experience of the others favors continuing and increasing their use of computers in the classroom.

This is not to say that there are not problems and annoyances connected to the successful integration of microcomputers in the curriculum. Malfunctioning machines, straying software, scheduling disappointments and missed appointments are among them. The fact that they are valuable public property, so teachers or other responsible adults must be on duty when they are being used is an inconvenience attendant on their successful use. But these features do not cloud the favorable response computer integration has evoked at Skyline.

SUMMARY OF FEATURES

The successful integration of computers into the curriculum at Skyline--where lots of teachers and lots of students use computers in lots of ways --is owed to a number of factors. The school, the district, county, state, and federal governments and the public environment foster it. The principal endorses it and actively, imaginatively and patiently promotes it. The school and district contain extraordinary people: the two Bevs, with their tremendous initiative, expertise and altruism; Loveless, with her strong leadership in support of teachers and computers; and Cradler with his officially-sanctioned commitment and his golden grant-writing touch. This talented group has mustered the hardware, software and training opportunities to provision the whole of Skyline. They have had the advice and encouragement of another extraordinary actor, Finkel, at the county level. In addition, they capitalized on cheap or free resources, such as student labor and PTA-donated carts, which help computers work throughout the school. And the computer innovation was molded to fit into Skyline's existing curricular priorities. The addition of problem-solving extends, but does not change Skyline's emphasis on basics. The uniformity of style and standards throughout the school and stability within the faculty foster the trust and communication which have contributed to the successful integration of computers at Skyline. Teachers see the utility of computers and are committed to incorporating them in the curriculum. Not only is the expectation for participation there, but so are the mechanisms to back it up. Success with computers at Skyline breeds more success.

POLICY IMPLICATIONS

That Skyline successfully integrates computers into its curriculum, by the working definition which has guided this discussion, cannot be doubted. But the policy considerations about the generalizability of their success open another set of questions. Which are the factors that are amenable to policy manipulation? Or, if one or another element were missing from Skyline, would computers still work as well there? Would

the complete set of factors produce the same result in another school, in another county, at another time?

An initial observation is that the factors are not independent of each other. The extraordinary people worked together, and were the agents through whom material was acquired and training for the majority of teachers was made possible and attractive. A second observation is that the amount and type of resources, and the relative ease with which they were acquired may have been specific to that location and time. Skyline's collection of seven computers (and sometimes nine) and a considerable library of software without major outright expenditures for either may be a function of its early prominence and experimentation among computer-using schools. New funding sources may develop, but some funding sources either will be depleted or diminished when a large number of schools petition to use them, too. Secondarily, Skyline's location near the heart of the electronics industry may also have made available resources and opportunities that other schools may not be positioned to get. Quite possibly, the initial training opportunities for the teachers who have so stamped computer use at Skyline would not have been as plentiful elsewhere, nor might parents have been as receptive to computer-based learning. When a second generation of schools begins to acquire training, equipment and programs to resemble Skyline's, it is possible that the level and quality of expertise in those schools will never really reach that of Skyline and other early-adopting schools whose extraordinary teachers had the entrepreneurial drive to explore, experiment and create.

Policy implications of achieving successful computer integration on the Skyline model extend beyond the school site to the district and the region. Questions such as those pertaining to hardware and software acquisition and adequacy, articulation of the curriculum, and provision of training, maintenance and on-going technical help, require answers from policymakers outside the local school. Policymakers at all levels must decide at what level the responsibilities for governance and finance lie, and what mechanisms best respond to the needs, and how coordination among levels may best be achieved.

Because integrating computers in the curriculum means incorporating both a subject in the curriculum and an instructional method, one set of policy issues involves regularizing pedagogical practices around computers. On the one hand, regarding computers as content raises questions about articulation within and among schools as well as districts, and about certification of computer teachers. On the other hand, regarding computers as instructional method raises questions about optimal ratios of students and teachers to computers, the amount of time students should be alloted on various computer applications, and the types of tasks for which this mode of instruction is best suited.

Another set of policy issues involves provision of technical supports for computer integration and should also be addressed at local and regional levels. Where, when and what kind of training should be offered, and how should the costs be distributed? What degree of hardware maintenance support should be provided and over how many classrooms or sites can it efficiently be spread? Similarly, what should be the service area of a software library and how should software evaluation be organized and sponsored? Within a site, a district or a region, what kinds of user networks, formal and informal, are needed to sustain and support the information and associational needs of lead computer teachers? What agency should convene or sponsor them, and in what way?

A final set of policy issues involves the formalization of roles within the site and district which contribute to successful integration of computers. Should job descriptions of lead teachers be altered to reflect their additional or different duties? Similarly, in what ways should roles of key computer students be recognized and variances in their programs or schedules be made? In what ways should parents participate in the computer innovation? For example, will the district provide training for parents or supervize lending of computer equipment to students' homes overnight?

FUTURE RESEARCH

These and the questions listed above represent some of the policy issues implicated in the integration of computers in an elementary

school curriculum. Not all factors which contribute to successful integration are subject to policy manipulation, although even some of the apparently most natural and spontaneous, such as lead teachers (whom Sheingold et al. 1983 label "computer buffs"), may turn out to be common enough that some way of creating them may eventually be found.

Other questions also remain. What are the universal or essential features for successful integration of computers? Do these features change from elementary to junior to senior high schools? Can a "second generation" of computer users match the performance of the first generation of early adopters? How much tolerance exists in the range of any of the necessary features? For example, what happens when the local site or district, or parents fund the majority of hardware purchases? What difference does it make if there are enough computers so that every teacher always has one, or few enough so that some teachers rarely have one? What will further refinement in the state of the art in computers or the development of newer educational technology mean for the integration of computers in the curriculum?

This study of successful integration of computers in the curriculum of an elementary school provides one case to corroborate findings from the research on planned change and to suggest new insights about the implementation of educational technology. Further research and the passage of time are necessary to answer the additional questions raised and to determine the extent to which the findings of the study may be generalized. Computers have arrived on the education scene, but further research and experience will have to determine their impact and staying power.

APPENDIX: METHODOLOGICAL NOTE

Although the whole study embraced interviews with several experts and visits to two additional successful computer-using schools in other districts, this paper reports only bservations and interviews at Skyline Elementary School in the South San Francisco (CA) Unified School District.

Skyline was selected from among three sites within the county adjacent to Stanford University that LeRoy Finkel, Instructional Computing Coordinato· in the San Mateo County (CA) Office of Education, nominated as successful. On the basis of his recommendation, Skyline's principal, Barbara Loveless, welcomed me and permitted me to "wander around and talk to people" there. Over seven days in a five-week period, approximately 26 hours were logged in contact with the site. Contacts included formal interviews with the principal, the district research and development officer, and seven teachers (some more than once), as well as observations of computer use in eight classrooms and in three auxiliary settings (after school in the principal's office, at the Computer Club, and at a teacher training workshop). Other contacts included informal interviews during observations along with conversations in the teachers' room and at other locations around the school.

Kindergarten and third through sixth grade classrooms were observed, as well as the RSP (remedial) room. Student use in observed classrooms ranged from one child to groups of three to four children at a single computer to whole classes of up to 23 children using nine computers. In one instance, two children and a teacher were stationed together at the terminal for a kindergarten lesson, and in another instance, the RSP teacher and all eight students worked at one computer. Applications covered computer programming, drill and practice and, only at the Computer Club, video games. Subject matter observed in computer use included problem-solving using LOGO (a computer language with a 'turtle' cursor), math and language arts.

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